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REPORT

CD NO.

50X1-HUM

COUNTRY	USSR	DATE OF INFORMATION	1949
SUBJECT	Scientific - Vacuum tubes	DATE DIST.	29 Jun 1950
HOW PUBLISHED	Monthly periodical		
WHERE PUBLISHED	Moscow	NO. OF PAGES	8
DATE PUBLISHED	Dec 1949	SUPPLEMENT TO REPORT NO.	
LANGUAGE	Russian		

THIS IS UNEVALUATED INFORMATION

SOURCE Radio, No 12, 1949.

TWIN TRIODES

A. Azet'yan

/Figures are appended./

Production of Types 6N8M and 6N9M tubes was begun considerably later than that of the 6N7S tube. Like the 6N7S, the two former tubes are combinations of two identical triodes in one bulb.

6N8M Twin Triode

The 6N8M twin triode hardly differs from the 6N7S in construction and outward appearance. Figure 1 shows a general view and base diagram for the 6N8M tube. It can be seen from the base diagram that the cathodes of the 6N8M tubes, in contrast to the 6N7S tube, are not connected to each other. This enables the 6N8M tube to be used also in cases where the triode cathodes are at different potentials, or where they must be completely isolated from each other.

The limiting values of voltage, current, and power permissible during testing and operation of the 6N8M tube are as follows:

Maximum plate voltage	300 volts
Minimum grid bias voltage	0 volts
Maximum heater voltage (with respect to cathode)	90 volts
Maximum value of the constant component of cathode current (the sum of the constant components of the plate and grid currents)	20 ma
Maximum plate power dissipation	2.5 watts

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These limiting values apply to one triode and are in accordance with the so-called average-rating system, which is based on the assumption that the supply voltages do not differ more than ± 10 percent from their nominal values. Naturally, if there are greater fluctuations the operating conditions should be lowered so that the limiting values never increase more than 10 percent. (It should be borne in mind that the emitting layer of an oxidized cathode will be destroyed by a large drop in filament voltage even with a simultaneous proportional decrease in plate voltage.)

Although the 6N8M twin triode is not specifically intended for audio amplification in a push-pull stage, it can be used in this way and gives satisfactory results in cases when it is necessary to use a plate voltage supply reduced to 100-140 volts.

Under Class A_2 conditions, without grid bias, one 6N8M tube can deliver a power of 0.8 watt with a plate voltage of 125 volts, load resistance between the plates of 7,000 ohms, and plate current 30 ma. For full excitation, the power of the preceding stage should be about 0.06 watt and can be obtained at the same plate voltage from one triode of the 6N8M tube operating under Class A_1 conditions, i.e., without grid current.

The interstage transformer connecting an input stage to a push-pull output stage should be of the step-down type. The turn ratio of one half of the secondary to the primary should be 1:5. By using the other triode of the 6N8M tube for preliminary audio-voltage amplification, it is possible to obtain a two-tube three-stage amplifier with an output of 0.8 watt. To obtain this power, it is necessary to supply an alternating voltage of 0.25 volt on the grid of the first tube.

The dependence of plate current I_a and grid current I_g on plate voltage, with zero voltage and various positive voltages on the grid, is shown in Figure 2. Due to the fact that the tube described has a medium amplification factor at zero bias and normal plate voltage of 250 volts, a very large plate current is obtained, as a result of which the power developed in the plate is several times as much as the maximum permissible power. Obviously, in order to use the 6N8M tube under Class AB_2 conditions with normal plate voltage, it is necessary to apply about 6-7 volts negative bias to the grids. This is difficult to achieve in practice, as a result of considerations examined in the description of the 6N7S tube.

Figure 3 shows the dependence of plate current of one triode on plate voltage for various values of negative grid voltage. Values of voltages and parameters for one triode of the 6N8M tube operating under Class A conditions with no load resistance in the plate circuit are as follows:

Filament voltage	6.3	6.3 volts
Filament current	0.6	0.6 amp
Plate voltage	90	250 volts
Grid voltage	0	-8 volts
Amplification factor	20	20 -
Plate resistance	6,700	7,700 ohms
Transconductance	3.0	2.6 ma/volts
Plate current	10	9 ma

NOTE: When the limiting voltage, current, or power is used, the ohmic resistance in the grid circuit of the triode should not be more than one megohm.

One triode of the 6N8M tube in a voltage amplifier circuit (resistance coupled) can give an amplification of from 11 to 14, depending on the magnitude of the resistance in the plate circuit, in the grid circuit of the tube of the following stage, and on the plate voltage. Table 1 shows this relationship for plate supply voltages of 180 and 300 volts. They have been compiled for various values of resistance R_a in the plate circuit (0.05, 0.1, and 0.25 megohms) and resistance R_g in the grid circuit of the following tube which operates without appreciable grid current. Table 1 and 2, C_c is the coupling condenser; C_k, the cathode bias condenser (across R_k); R_a, the plate load resistance, R_g, grid resistance; and U_{mg}, the voltage across R_g which is applied to the following grid.

Table 1. Plate Supply Voltage 180 volts

R_a		0.05			0.1			0.25		megohm
R_g	0.05	0.1	0.25	0.1	0.25	0.5	0.25	0.5	1.0	megohm
R_k	1190	1490	1740	2330	2830	3230	5560	7000	8110	ohms
C_k	3.27	2.86	2.06	2.19	1.35	1.15	0.81	0.62	0.5	mfd
C_c	0.06	0.032	0.0115	0.038	0.012	0.006	0.013	0.007	0.004	mfd
U^{1}_{mg}	24	30	36	26	34	38	28	36	40	volts
K^{2}	13	13	13	14	14	14	14	14	14	--

Plate Supply Voltage 300 volts

R_a		0.05			0.1			0.25		megohm
R_g	0.05	0.1	0.25	0.1	0.25	0.5	0.25	0.5	1.0	megohm
R_k	1020	1270	1500	1900	2440	2700	4590	5770	6950	ohms
C_k	3.56	2.96	2.15	2.31	1.42	1.2	0.87	0.64	0.54	mfd
C_c	0.06	0.034	0.012	0.035	0.0125	0.0065	0.013	0.0075	0.004	mfd
U^{1}_{mg}	41	51	60	43	56	64	46	57	64	volts
K^{2}	13	14	14	14	14	14	14	14	14	--

The values given for the capacitances C_k and C_c are those which at a frequency of 100 cycles cause the AC voltage at R_g to drop to 0.8 of the AC voltage at R_a. If it is desirable to have this decrease of amplification at any other low frequency such as f_1, the table value of the capacitance of condensers C_k and C_c must be multiplied by the ratio $100/f_1$.

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Comparison of the two sections of Table 1 shows that the values of resistances, capacitances and amplification factor depend only slightly on the voltage supply to the plate circuit. Therefore, the values given can be used without correction if the supply voltage is not more than 50 percent different from the nearest tabulated value (180 or 300 volts). As regards the output voltage, it changes proportionally to the plate circuit supply voltage. Preference should be given to the variant with the greater value of R_g, but in such a way that the limit for the permissible value of ohmic resistance in the grid circuit of the following tube is not exceeded.

The use of the 6N8M twin triode to amplify low-frequency voltage in a resistance-coupled amplifier makes sense when it is necessary to obtain an additional 12- 14-fold amplification and when there is, or should be, a triode with similar parameters in the set (e.g., a 6Zh5 or a 6S5M). In this case, the 6N8M tube enables one to obtain additional amplification without increasing the total number of tubes in the set.

The 6N8M triodes can also operate in two adjoining audio-amplification stages giving an over-all amplification of 200. It is also possible to use the 6N8M tube in high-frequency amplification stages, provided that due consideration is taken of the properties common to all receiving triodes used for this purpose.

In addition, it is feasible to use the 6N8M tube in sets where two identical triodes are required or are desirable in various push-pull and bridge systems, etc. Due to its small plate resistance, the 6N8M tube is the most suitable twin triode for a blocking oscillator with a discharge tube.

<u>6N9M Twin Triode</u>

The external appearance, base diagram, and dimensions of the 6N9M twin triode are the same as those of the 6N8M, except for the fact that the triode filaments are connected in series, as each of them is designed for 3.15 volts and 0.3 amp.

The limiting values of voltages and powers permissible for one triode during testing and operation of the 6N9M tube are as follows:

Maximum plate voltage	250 volts
Minimum grid bias voltage	0 volts
Maximum heater voltage (with respect to cathode)	90 volts
Maximum plate power dissipation	1.0 watt

Figure 4 shows the relationship between the plate current of one triode and the plate voltage for various values of grid voltage. The voltages and parameters given below refer to one triode of the 6N9M tube operating under Class A conditions with no load resistance in the plate circuit.

Filament voltage	6.3 volts
Filament current	0.3 amp
Plate voltage	250 volts
Grid voltage	-2 volts
Amplification factor	70
Plate resistance	44,000 ohms
Transconductance	1.6 ma/volts
Plate current	2.3 ma

One triode of the 6N9M tube in a resistance-coupled voltage amplifier can give an amplification of from 25 to 49, depending on the magnitude of the resistance in the plate circuit, the resistance in the grid circuit of the following tube and the plate voltage. This relationship is shown in Table 2 below for plate supply voltages of 180 and 300 volts. The tables have been compiled for various combinations of resistance R_a in the plate circuit (0.1, 0.25 and 0.5 megohms) and resistance R_g in the grid circuit of the following tube which operates without appreciable grid current. The size of condenser C_c is chosen so that at a frequency of 100 cycles the voltage on resistance R_g is 90 percent of the voltage on resistance R_a. The method of calculating C_c if this voltage reduction is required at another frequency was explained above.

Table 2. Plate Supply Voltage 180 volts

R_a		0.1			0.25			0.5		megohm
R_g	0.1	0.25	0.5	0.25	0.5	1	0.5	1	2	megohm
R_k	1920	2140	2440	3700	4300	4800	6100	6840	7780	ohm
C_c	0.031	0.012	0.007	0.011	0.006	0.003	0.006	0.003	0.002	mfd
U^1_{mg}	17	24	27	21	28	32	24	32	36	volts
K^2	25	29	33	35	39	41	40	43	45	

Plate Supply Voltage 300 volts

R_a		0.1			0.25			0.5		megohm
R_g	0.1	0.25	0.5	0.25	0.5	1	0.5	1	2	megohm
R_k	1500	1860	2080	2800	3360	3680	4660	5960	6560	ohm
C_c	0.033	0.014	0.007	0.012	0.006	0.003	0.006	0.003	0.002	mfd
U^1_{mg}	35	50	54	45	55	64	50	62	72	volts
K^2	29	34	36	39	42	45	45	48	49	

NOTE: i. In Tables 1 and 2 the value shown for the amplitude of the voltage on resistance R_g is such that an increase would cause a current to flow in the grid circuit of the tube in question.

ii. The voltage amplification factor when $U_{mg} = 7.1$ v.

As in the preceding cases, if the plate voltage used differs from the nearest value given in the table (180 or 300 volts) by not more than 50 percent, the resistance, coupling capacitance, and amplification factor K of the stage need not be recalculated. An exception is the case of the output voltage which changes in proportion to the plate circuit supply voltage. When selection a variant, preference should be given to large values of R_g, but they must not exceed the maximum allowable ohmic resistance in the grid circuit of the following tube.

The triodes of the 6N9M tube can also operate in two adjoining audioamplification stages. In this case, one tube can give an amplification of up to 2,400.

The 6N9M tube can be successfully used, as can the 6N9M, in various low-power push-pull and bridge circuits, mixers, blocking oscillators, etc. As compared with the 6N9M [sic] and 6N7S tubes, it has the advantage that less filament current is needed.

The use of a twin triode for phase inversion in a broadcast receiver with a push-pull output is quite feasible.

Figure 5 gives a circuit for the phase-inversion stage using a twin triode. Due to the fact that the cathodes of the triodes are connected to each other, the 6N7S tube can be used as well as the 6N8M and the 6N9M. The amplified low-frequency voltage is applied to the grid of one of the triodes (in this case, the left-hand one). The AC voltage with inverted phase is applied to the grid of the right-hand triode from part of the resistance in the grid circuit of the following (usually the final) stage. The position of the tap on this resistance should be such that the AC voltages on the grids of the left and right triodes are equal in magnitude. The ratio of the two sections of such a voltage divider (practically, the ratio of two separate resistances) is determined by the voltage amplification factor K, which is given in Table 2. For example, we find from the table that one triode of the given tube type under certain conditions gives an amplification K equal to 25. Then the resistance R_g consists of two resistances such that their sum shall be equal to R_g, and the resistance between the grid of the right-hand triode and the grounded point shall equal 1/25 of the total value of R_g. The values of the resistances R_a, R_g and the capacitances C_c are taken from the tables.

The resistance R_k should be half that shown in Table 2 as both triode currents pass through it simultaneously.

The condenser C_k which shunts the bias resistance is not needed in the phase inversion stage to eliminate negative feedback. The fact is that the parameters of one triode of the tube are usually slightly different from the parameters of the other triode. As a result of this, the AC voltages, although they will be shifted through a phase angle of 180 degrees, will not be equal in magnitude. In the case where the parameters of the triodes are different and the resistance R_k is not shunted, negative feedback will arise which will result in both voltages being in nearly complete balance.

In order to select the correct type of twin triode for the phase inversion stage and to select the circuit elements, it is necessary to know the excitation voltage for the final stage. It is easy to determine the most suitable type of triode from the above tables.

[Figures follow.]

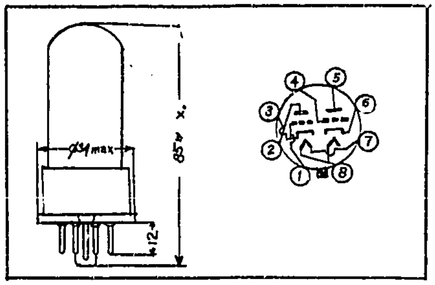

Figure 1.

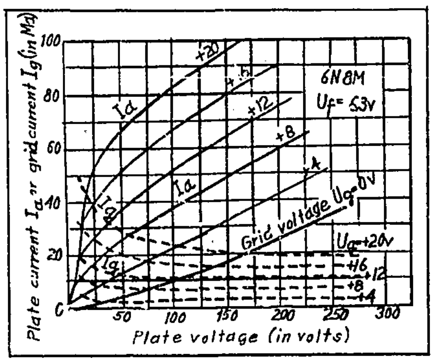

Figure 2.

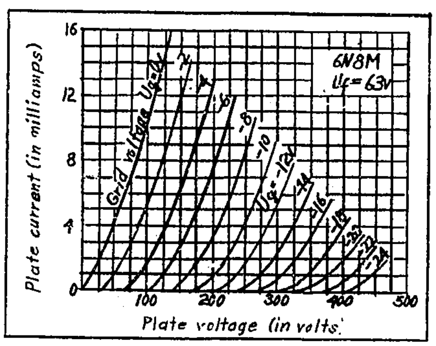

Figure 3.

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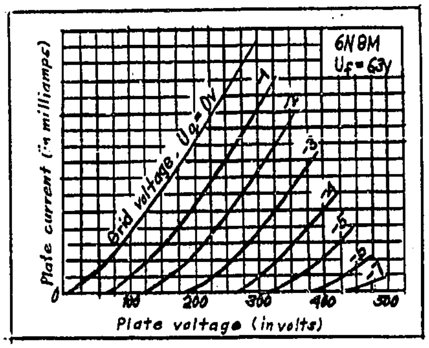

Figure 4. Plate Current Plotted to Scale: 1 div = 0.5 ma

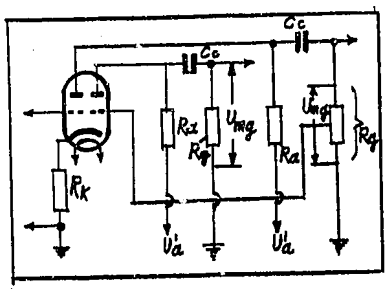

Figure 5.

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